

GOCE – Validation of last days' orbits with kinematic PPP

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G1.3

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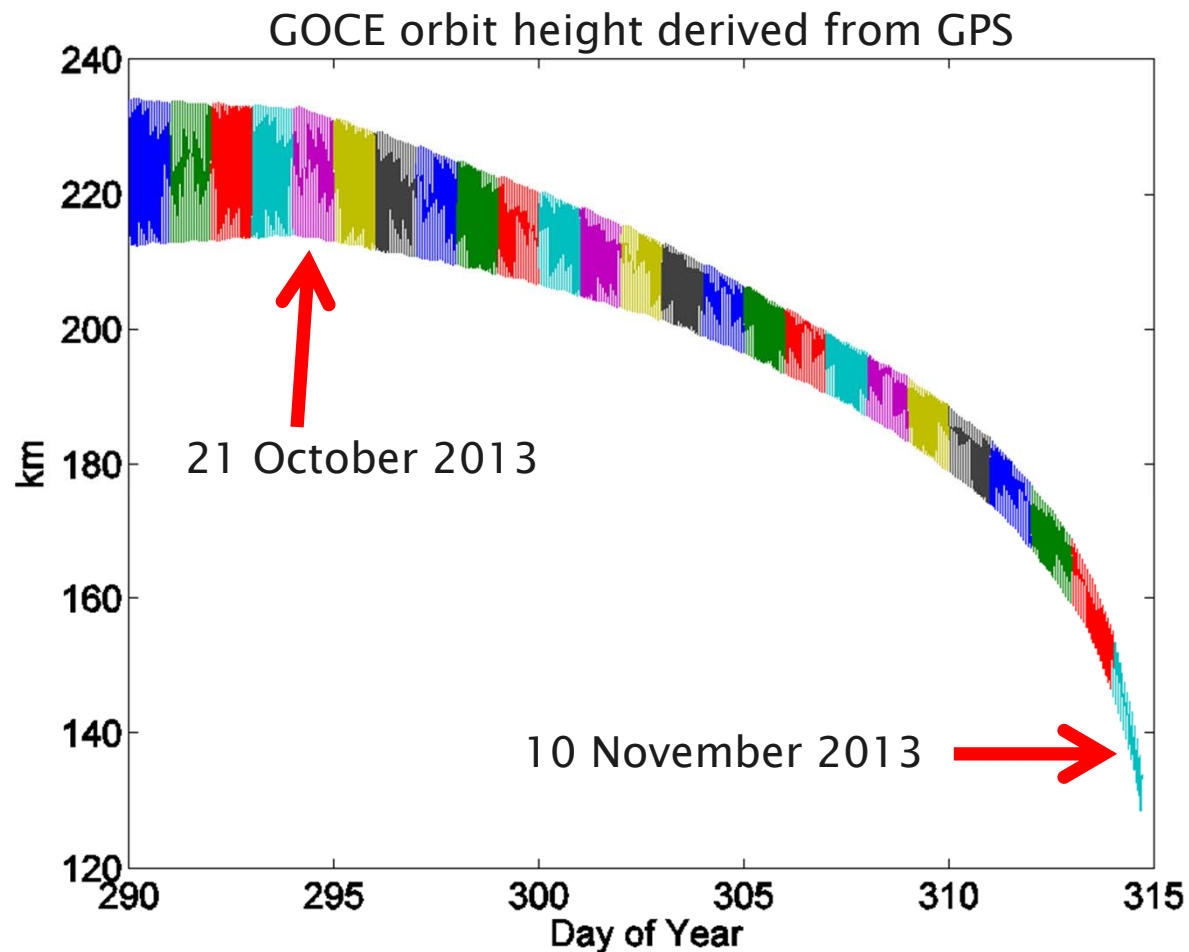
Vienna, Austria

Background and Motivation

- The first ESA Earth Explorer core mission GOCE ended officially on 21 October 2013, because the satellite ran out of fuel.
- Three weeks later, on 11 November 2013, the satellite re-entered the Earth's atmosphere near the Falkland Islands in the South Atlantic.
- GPS-based orbit determination was possible until few hours before re-entry.

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Background and Motivation



- Last available GPS measurements: 10 November, 17:15:20 UTC

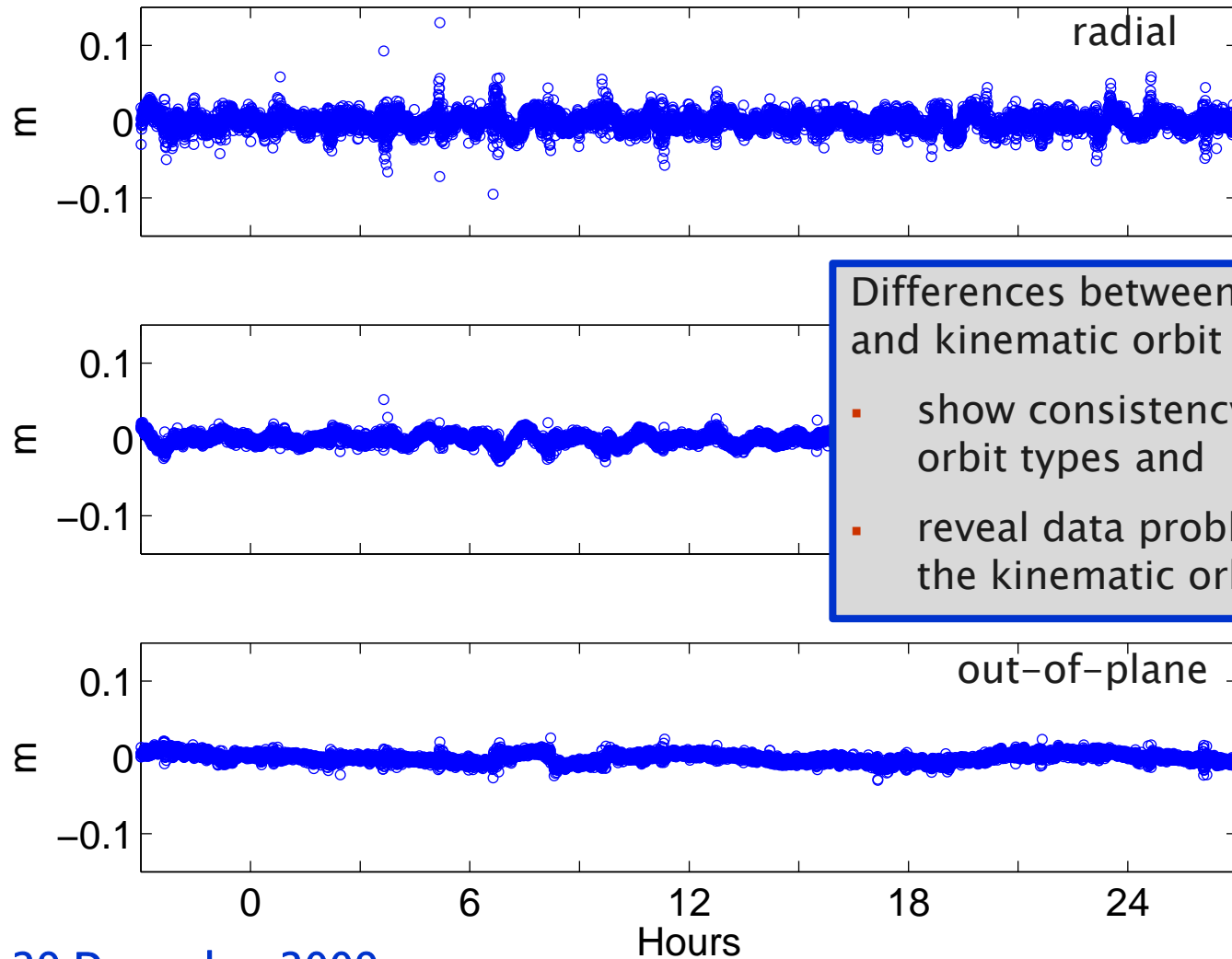
Background and Motivation

- In the frame of the European GOCE Gravity Consortium (EGG-C) AIUB was responsible for the generation of the GOCE Precise Science Orbit (PSO) product.
- The PSO product consists of a reduced-dynamic and a kinematic orbit (comparable to a kinematic PPP of a ground station).
- Internal validation: Orbit overlap analysis and differences between reduced-dynamic and kinematic orbits for consistency checks.
- External validation: Satellite Laser Ranging (SLR) measurements.
- Reduced-dynamic orbits were generated with the same orbit parameterization for the entire mission.

Two main questions for this study:

- Can the kinematic orbits/PPP be used for validation, because SLR measurements are no longer available (only three passes)?
- Is the orbit parameterization of the reduced-dynamic orbit still reasonable for the last three weeks of GOCE?

Differences red.-dyn. \Leftrightarrow kinematic orbits

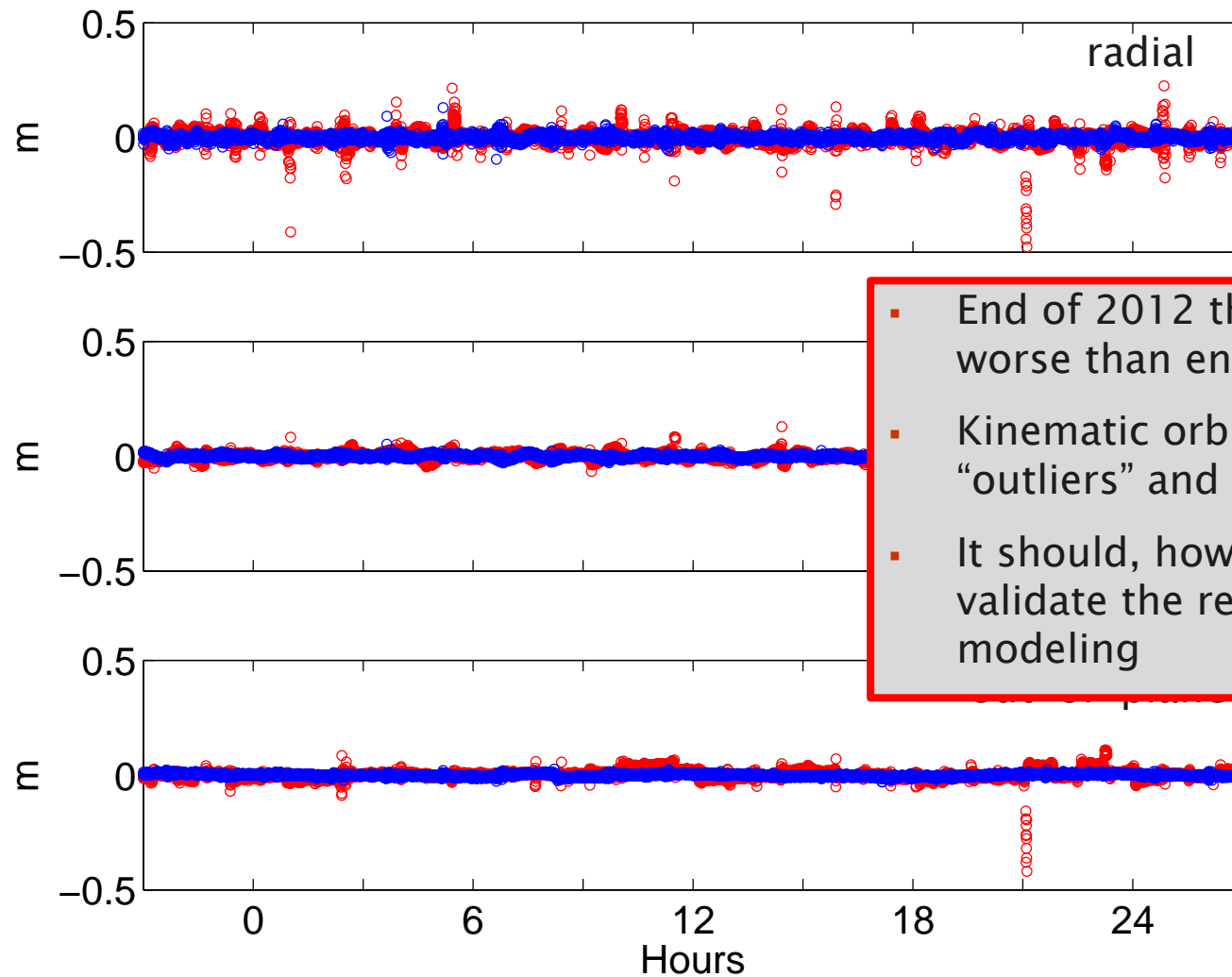


Differences between reduced-dynamic and kinematic orbit

- show consistency between the two orbit types and
- reveal data problems and gaps in the kinematic orbit

29 December 2009

Differences red.-dyn. \Leftrightarrow kinematic orbits

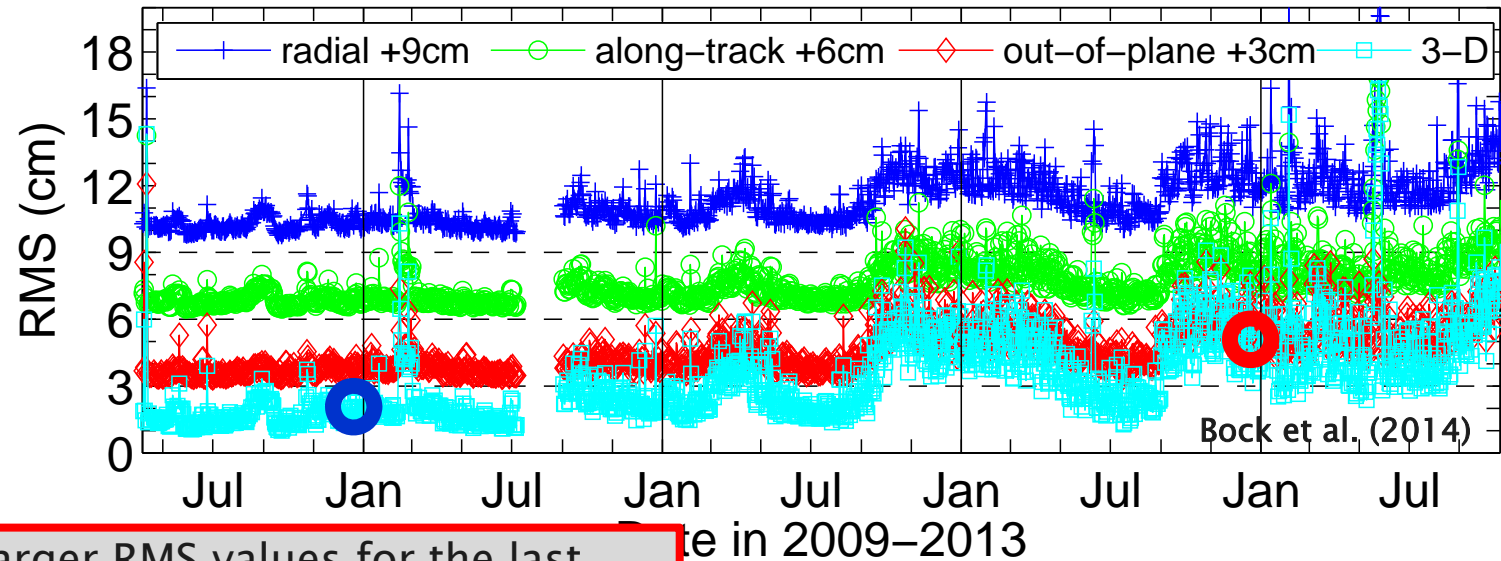


- End of 2012 the data quality is worse than end of 2009
- Kinematic orbit shows more “outliers” and systematic effects
- It should, however, be possible to validate the reduced-dynamic orbit modeling

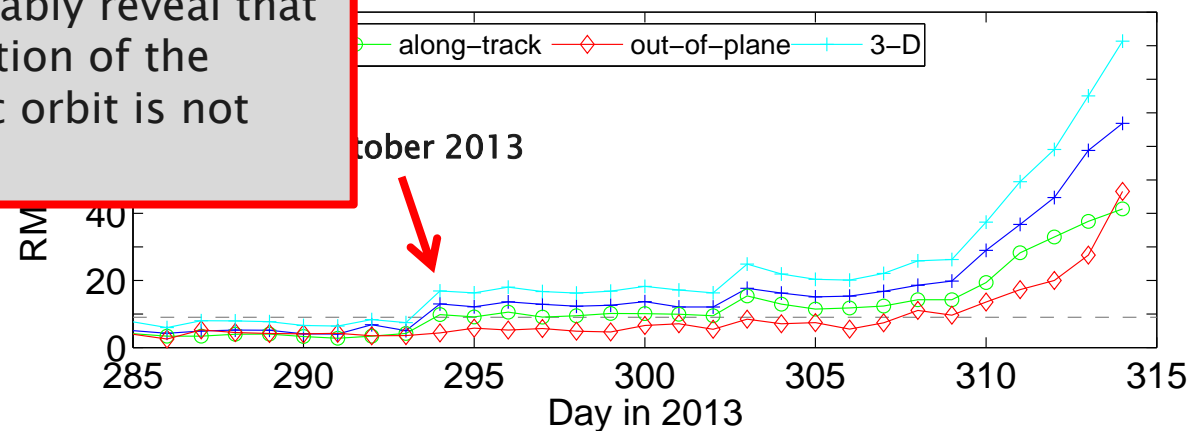
28 December 2012 and 29 December 2009

GOCE internal orbit validation

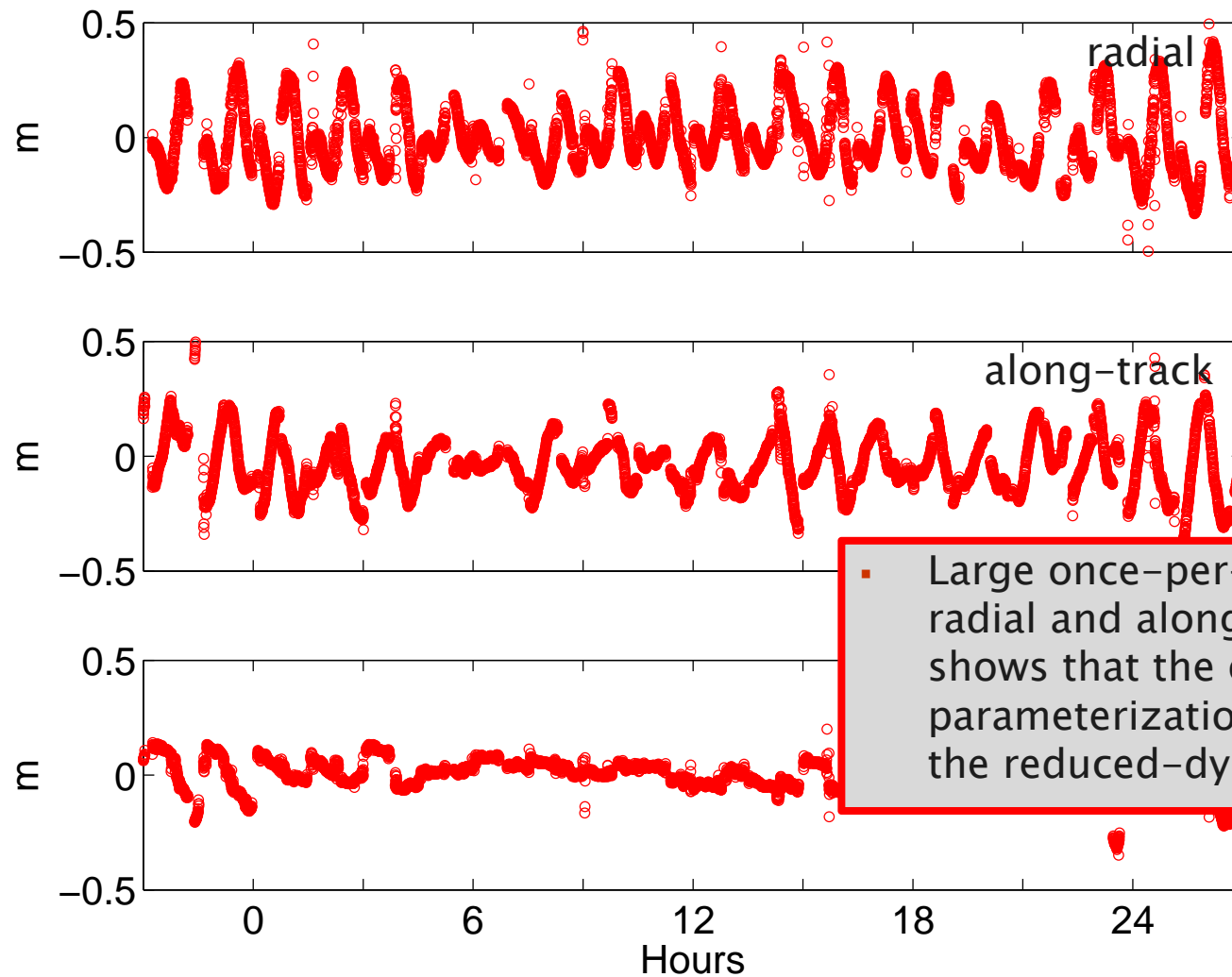
RMS of differences between red.-dyn. and kinematic orbits for official mission



- Larger RMS values for the last three weeks probably reveal that the parameterization of the reduced-dynamic orbit is not ideal at all



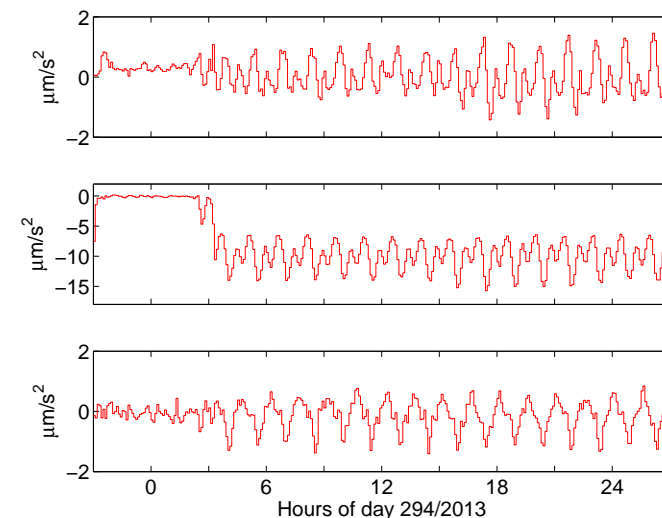
Differences red.-dyn. \Leftrightarrow kinematic orbits



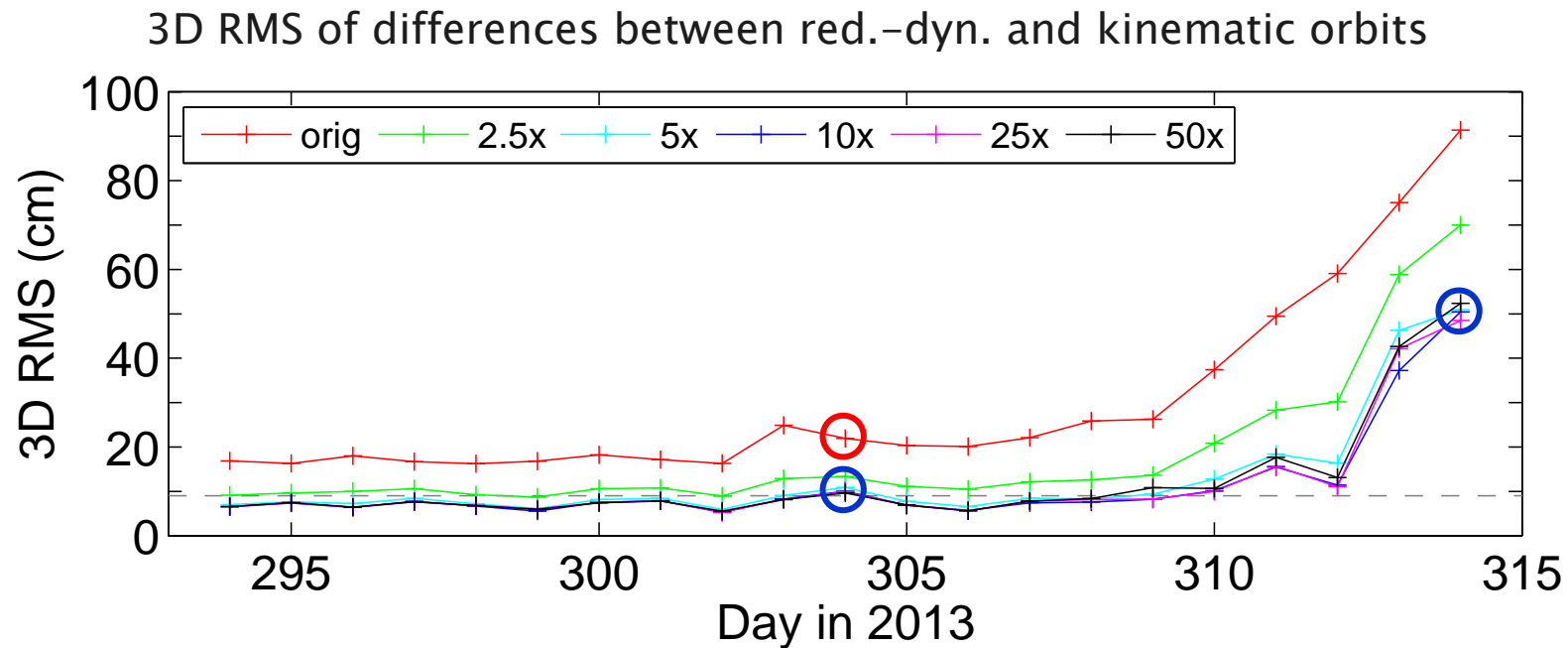
Original solution; 31 October 2013

Reduced-dynamic orbit determination

- 30 h processing batches (not for the last 10 days), 10 s sampling, undifferenced processing, ionosphere-free linear combination, CODE Final GNSS orbits and clocks (5 s) and Earth Rotation Parameters
- Orbit models and parameterization:
 - EIGEN5S 120x120, FES2004 50x50 (fixed by GOCE Standards)
 - Six initial orbital elements
 - Three constant accelerations in radial, along-track, out-of-plane
 - 6-min piece-wise constant accelerations in radial, along-track, out-of-plane ($2 \times 10^{-8} \text{ m/s}^2$)
- Test solutions with weaker constraints:
 - $2.5 \times 2 \times 10^{-8} \text{ m/s}^2$
 - 5 x
 - 10 x
 - 25 x
 - 50 x

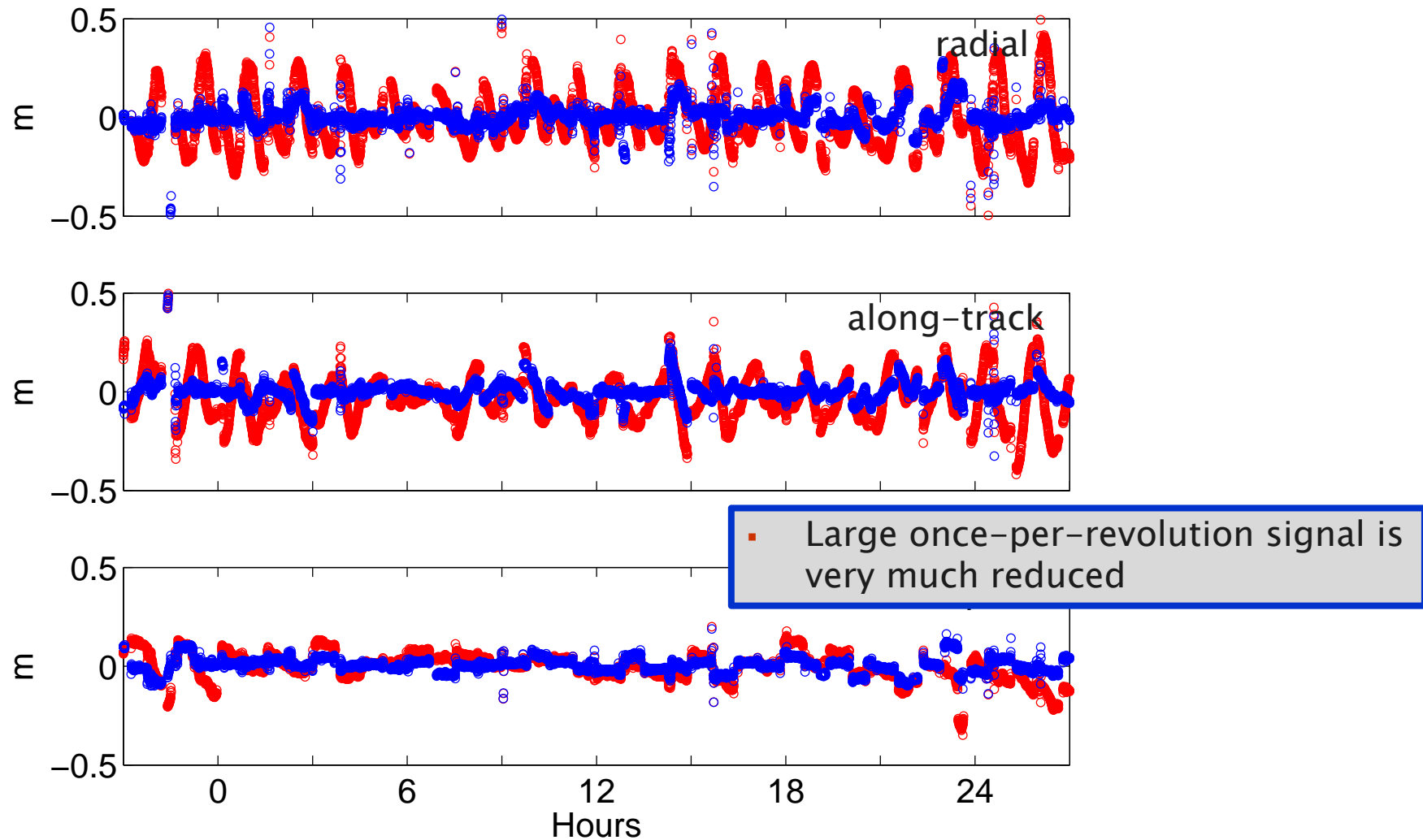


Solutions with weaker constraints



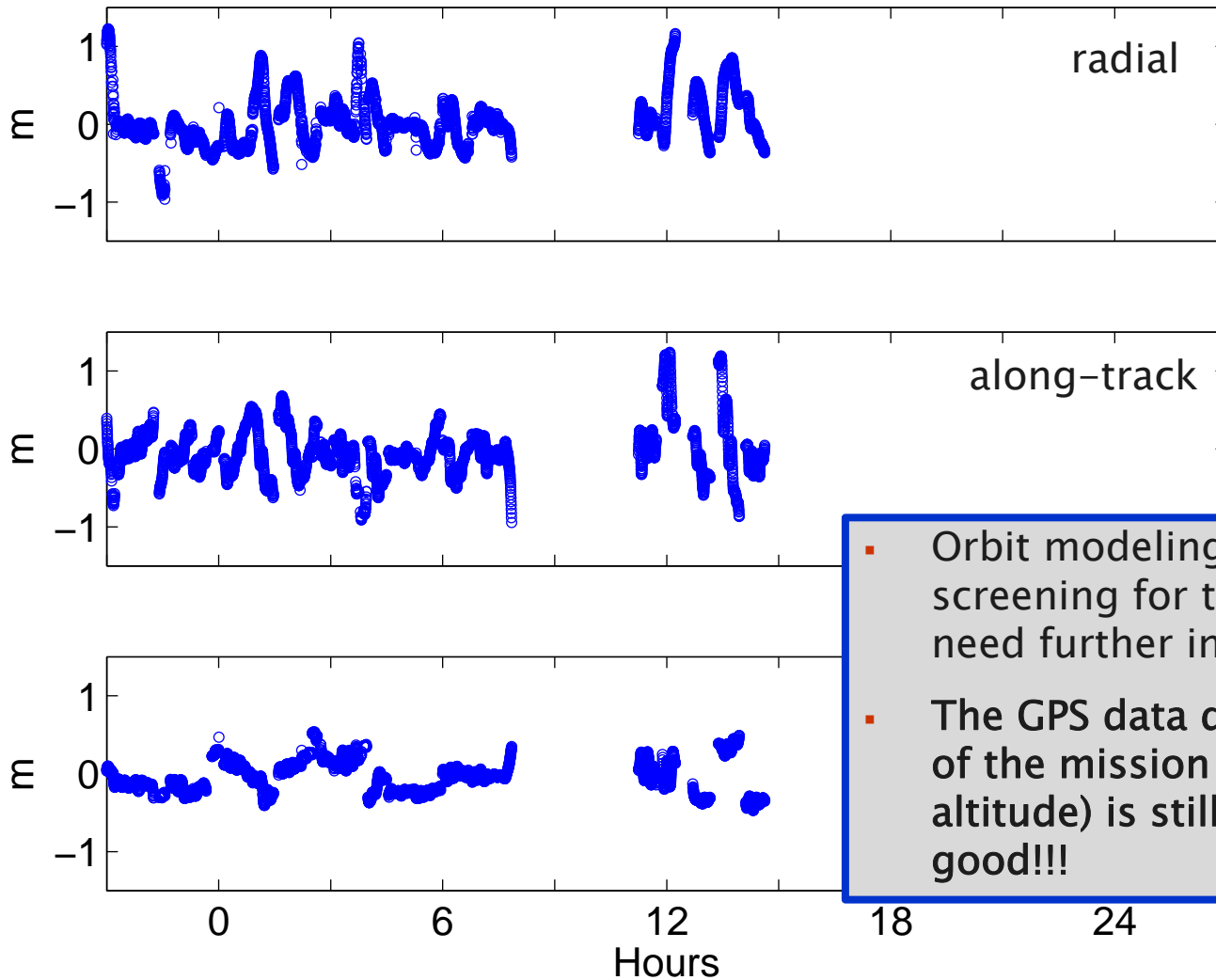
- Test solutions with weaker constraints show better consistency with kinematic orbits.
- Differences between 5x and 50x weaker constraints are marginal.
- Except the very last days, these solutions are acceptable.

Differences red.-dyn. \Leftrightarrow kinematic orbits



Original solution and 10x weaker constraints; 31 October 2013

Differences red.-dyn. \Leftrightarrow kinematic orbits

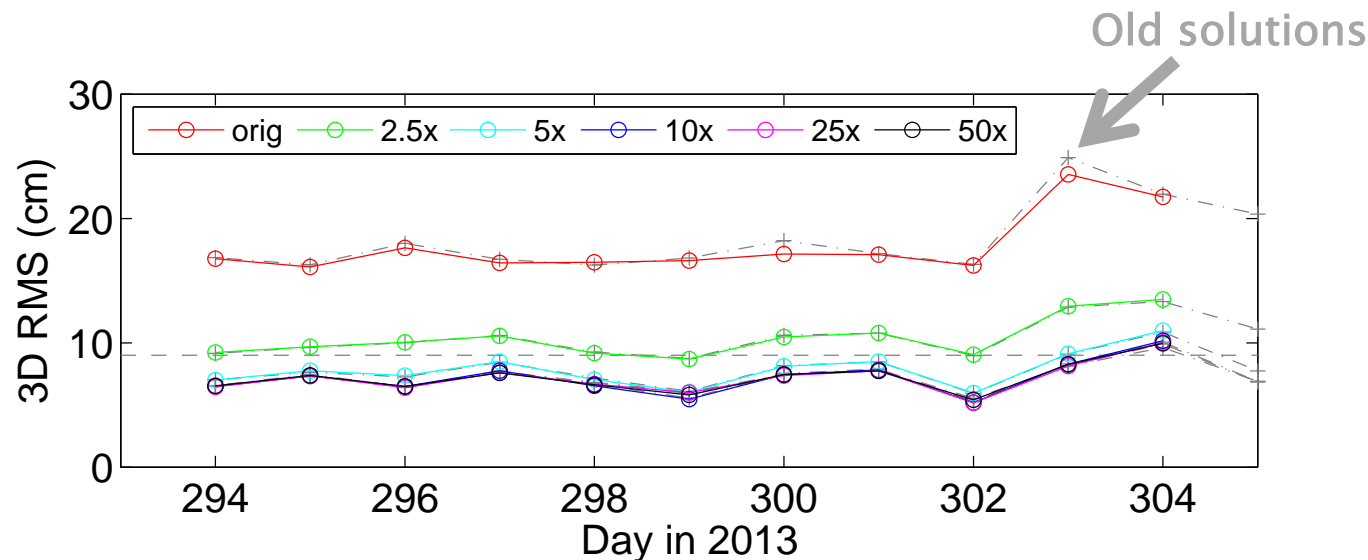


- Orbit modeling and data screening for the very last hours need further investigations
- The GPS data quality at this stage of the mission (150 – 130 km altitude) is still surprisingly good!!!

10x weaker constraints; 10 November 2013

Improved background modeling

- In order to improve the background models the gravity field model EIGEN5S 120x120 is replaced by GOCO03S 200x200 for the first 11 days of the decay phase.
- Test solutions with original and weaker constraints are repeated.



- No or only small improvements with respect to the old solutions can be noticed with the better gravity field model.

Summary

- Can the kinematic orbits be used for validation? => Yes, except that the very last hours/days are difficult because of data screening problems leading to larger data gaps.
- Is the orbit parameterization of the reduced-dynamic orbit still reasonable for the last three weeks of GOCE? => No, the constraints are too tight; 10x weaker constraints are reasonable.
- First updates in the background modeling of the reduced-dynamic orbit determination did not improve the results of the reduced-dynamic orbits.

Further work:

- Detailed check of background modeling and sampling of piece-wise constant accelerations.
- Improve data screening procedure for the very last days/hours.
- Comparison with and possibly use of accelerometer data in the reduced-dynamic orbit determination (as long as they are available).